CIRCULATION OF MARGINAL AND SEMI-ENCLOSED SEAS (SEA OF JAPAN AND RELATED PROCESS STUDIES)

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LONG-TERM GOALS

My basic goal is to understand the general principles governing the mean and transient circulation in realistic marginal and semi-enclosed seas, especially the roles of mesoscale variability. My applied goal is to improve the scientific basis for the design of nowcast/forecast systems to be implemented in marginal and semi-enclosed seas. I am particularly interested in treating realistic continental margins and realistic atmospheric and throughflow forcing for such seas, using numerical simulation and data assimilation models for the circulation.

OBJECTIVES

My scientific objectives include:

1) developing methods for dealing with open boundary forcing of marginal and semi-enclosed seas due to the large-scale external circulation;
2) developing methods for model validation; i.e., for quantitative validation of models versus observations;
3) conducting model versus observations comparisons;
4) conducting model versus model comparisons; and
5) conducting observing system design studies through numerical simulation.

APPROACH

The Princeton Ocean Model (POM), as implemented for the Sea of Japan (SOJ) with mesoscale eddy-admitting resolution, is used for sensitivity and process studies. Model simulations are evaluated in comparison to CREAMS current meter time series. Ms. HeeSook Kang carries out these calculations for her graduate research project. Dr. Jia Wang provides technical advice and is responsible for the POM implementation in Prince William Sound and the Labrador Sea, where an ice coupling strategy is being developed. Ms. Renellys C. Perez has been making model versus observations comparisons in the Gulf of Mexico and will soon shift to data assimilation studies with SOJ-POM. Mr. Derrick Snowden is beginning to implement a model for Prince William Sound that has an open boundary well offshore in the Gulf of Alaska to explore use of the NCEP Pacific Ocean Re-Analysis for open boundary conditions. Prof. Victor I. Kuzin, RAS (Akademgorodok), has implemented a finite element model for SOJ so that model-model comparisons can soon begin.

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WORK COMPLETED

Our SOJ-POM implementation has been used to conduct sensitivity studies relative to throughflow strength and structure, different climatological atmospheric forcing fields, and increased vertical resolution. It has also been used to make statistical comparisons to CREAMS current meter data, prior to introducing seasonally varying and synoptic atmospheric forcing. And it has been used to perform a case study for the circulation and convective response to impulsive forcing (windstress, heat flux, and moisture flux) characteristic of Siberian cold air outbreaks.

RESULTS

With ca. 10km horizontal resolution, a 26 (sigma) level simulation (with relatively high resolution in surface and bottom boundary layers) yielded results superior to 15 and 20 level simulations. The major circulation feature of the SOJ is the cyclonic gyre over the Japan Basin, and which is the locus of strong mesoscale variability and topographic coupling of barotropic and baroclinic modes, as can be seen from the 1,000-day mean and standard deviation fields for the sea surface height (SSH) and depth-integrated stream-function (ISF) (Fig. 1). Comparison of the 26-level simulation (with steady forcing) versus CREAMS intermediate level current meter data over the Japan Basin for 1,000-days indicated close agreement of the spectral levels and slopes for the oceanic mesoscale frequency band but (understandably) two orders of magnitude lower energy levels in the atmospheric synoptic frequency band (Fig. 2). However, the model mean flows were substantially greater than the observed mean flows for unknown reasons. The detailed structure of the upper layer circulation is also quite sensitive to the forcing and vertical resolution.

IMPACT/APPLICATIONS

A well-validated modeling system for marginal and semi-enclosed seas in general, and the Sea of Japan in particular, will form the basis for an ocean (circulation) prediction system. As such, it will form the basis for observing system design studies and hypothesis development. It will also form the basis for marine ecosystem, sediment transport, etc. simulation models.

TRANSITIONS

The results will aid in the final design of the CREAMS II field experiment. NRL (SSC) NAVO, and FNMOC are briefed annually on progress and plans.

RELATED PROJECTS

POM is also being used in simulations of the circulation of Prince William Sound (PWS) and the Intra-Americas Sea (IAS). PWS is a much smaller domain than SOJ, while IAS is significantly larger. Both PWS and IAS, as SOJ, are strongly influenced by throughflow and atmospheric forcing. PWS, unlike SOJ and IAS, is also strongly influenced by tidal forcing. SOJ and PWS, unlike IAS, are significantly influenced by wintertime ventilation and occasionally deep convection. Thus, these three domains have important dynamical similarities and differences, allowing exploration of general principles in different parts of parameter space. The Dynalysis of Princeton POM implementation for the Gulf of Mexico is the subject of an ongoing evaluation in comparison to the copious LATEX datasets.

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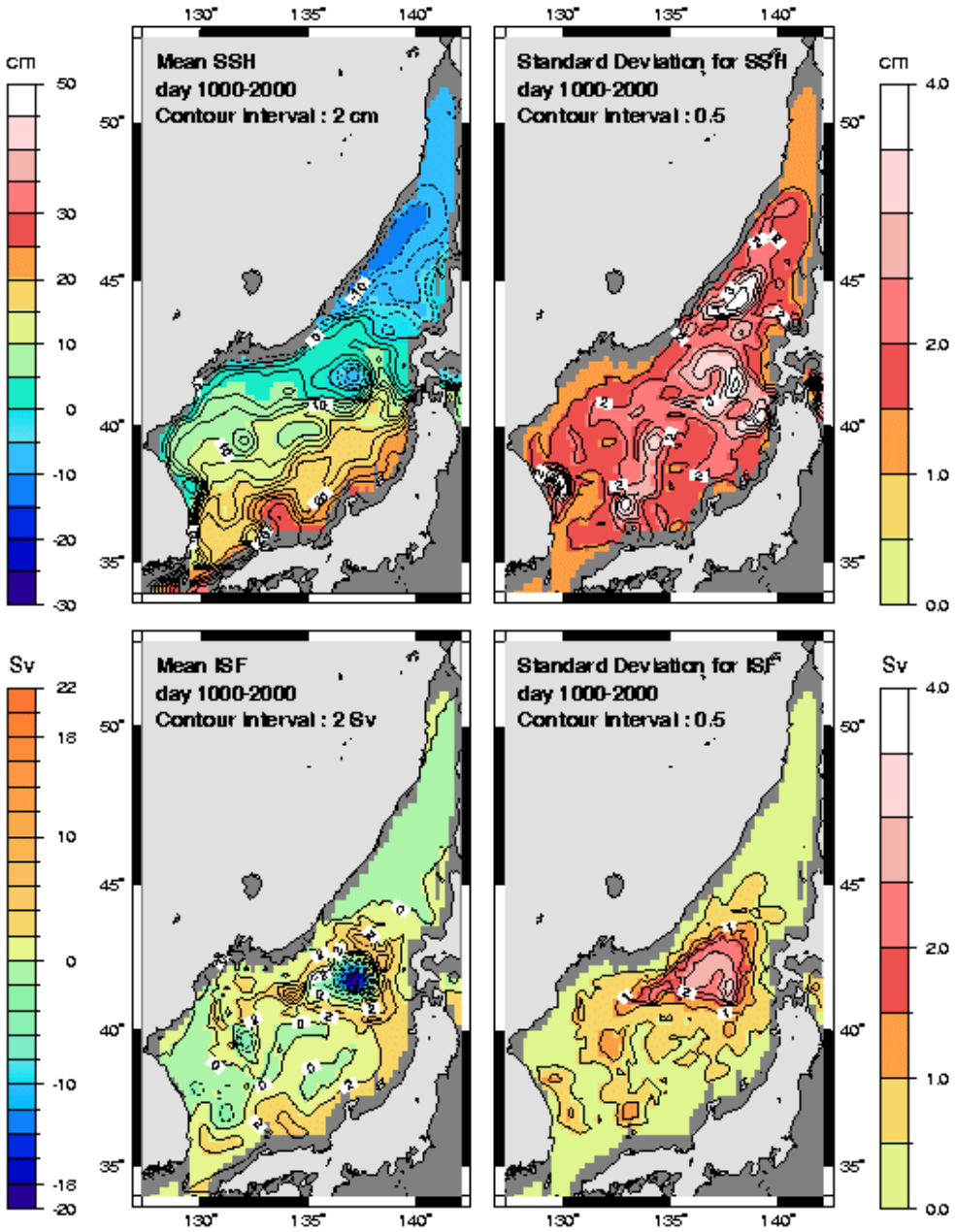

Figure. 1 Mean and standard deviation of sea surface height (SSH) and depth-integrated streamfunction (ISF).

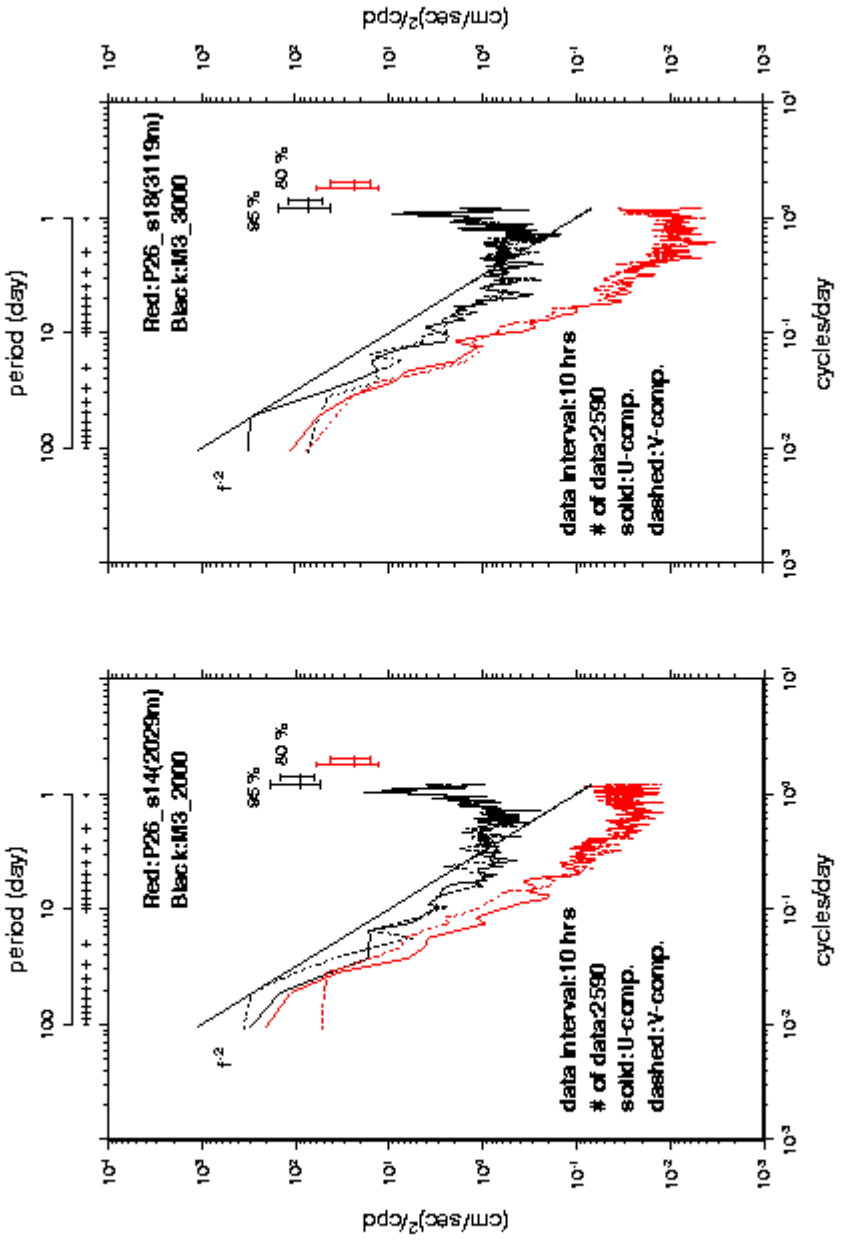

Figure. 2 Frequency-domain comparison of model output (red) versus CREAMS (Prof. M. Takematsu) current meter data (black) at 2,000 and 3,000 m in Japan Basin.